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NEWS AND REVIEWS

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NEW BRUNSWICK, NEW JERSEY, U. S. A

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INTERACTION OF 2,4-D MALEIC HYDRAZIDE, AND MINOR ELEMENT UPTAKE IN POTATOES[1]

E. Merle Harrison, Jess L. Fults and Merle G. Payne[2]

The San Luis Valley of Colorado has a type of soil and climate where only a few crops can be successfully grown. Potatoes are the principal crop, particularly the Red McClure variety. There is both positive and negative evidence of minor element deficiencies in the soils of the San Luis Valley. Because of reports of increased yields and quality of corn in Iowa and the Dakotas, this experiment was undertaken on an exploratory basis to determine if dusts containing 2,4-D[3] and minor elements could be used to advantage on Red McClure potatoes when applied in a foliar application. Since 2,4-D causes increased enzyme activity, there is a possibility that its use on growing potato plants might cause an immediate, localized requirement for certain minor elements that are connected with enzymes. If these minor elements were available at the sites of greatest metabolic activity, the plants might evidence increased growth and changes in metabolism as compared with controls.

Materials and Methods

The dusts used were commercial preparations[4] of the following composition: (1) 1 per cent 2,4-D, (2) 5 per cent 2,4-D and (3) 1 per cent 2,4-D and 2 per cent maleic hydrazide. All the dusts contained the minor elements boron, copper, iron, manganese and zinc.[5]

The treatments were applied to five one-acre plots, each 1200 feet long and 12 rows wide. The treatments were: (1) a control with no treatment, (2) 2,4-D at ½ pounds per acre in 35 gallons of water spray, (3) 1 per cent 2,4-D and minor element dust, (4) 5 per cent 2,4-D and minor element dust, and (5) 1 per cent 2,4-D, 2 per cent maleic hydrazide and minor element dust. Eight pounds of dust as received were added to 22 pounds of dusting sulfur as a carrier and applied to 1 acre. Each 1200 foot row was divided into twelve 100-foot sections. The 100-foot sections at each end were disregarded. Only the 2 rows in the center in each of the 5 plots were harvested. One crate of potatoes was gathered from each sub-plot, making 10 crates from each plot. The total yield of the center two rows for each 100-foot section was also recorded.

Data were collected for the yield, minor element concentration of the tubers using an emission spectrograph, total nitrogen in tuber juice (3), catalase activity in tuber juice (1), free amino acids in tuber juice (5), and sprout data.

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[1]Accepted for publication October 24, 1957. Published with the approval of the Director, Colorado Agricultural Experiment Station, as Scientific Series Paper No. 525. Agriculture Experiment Station, Colorado State University, Ft. Collins, Colo.

[2]Graduate Assistant, Department of Chemistry; Botanist, Department of Botany and Plant Pathology; Associate Chemist, Department of Chemistry, respectively.

[3]2,4-dichlorophenoxyacetic acid.

[4]Formulated by Chemical Machines, Ltd., 120 Lombard Avenue, Winnipeg 2, Manitoba, Canada.

[5]Boron, 1 per cent as borax; Copper, 2.6 per cent copper sulfate; Iron, 2.4 per cent iron sulfate; Manganese, 4.0 per cent manganese sulfate; Zinc, 3.2 per cent zinc sulfate.

TABLE 1.—*Yield, total nitrogen, catalase activity, and sprouting data.*

Treatments	Yield Data		Total Nitrogen		Catalase Activity		Sprouting Activity	
	Average Weight Tubers per 200 Ft. of Row	Difference from Control	Mg. of Total Nitrogen per Ml. of Juice	Difference from Control	Microliters of Oxygen[5]	Difference from Control	Weight of Sprouts from 25 Potatoes	Difference from Control
	Pounds	Pounds	Milligrams	Milligrams	Microliters	Microliters	Grams	Grams
Control-No. treatment	358.1[4]	....	3.04	....	6,916	....	137.5	....
2,4-D Spray at ½ lb. acid equivalent per acre	374.4	+16.3	2 70	—0.34*	5,292	—1,624**	76.0	—61.5**
1 per cent 2,4-D plus minor elements in a dust	389.9	+31.8	2.90	—0.14	5,102	—1,814**	139.5	+ 2.0
5 per cent 2,4-D plus minor elements in a dust	376.5	+18.4	2.99	—0.05	4,404	—2,512**	106.5	—31.0
1 per cent 2,4-D, 2 per cent maleic hydrazide plus elements in a dust	425.1	+67.0	3.50	+0.46**	4,695	—2,221**	96.0	—41.5*

*Difference significant at 5 per cent level.
**Difference significant at 1 per cent level.
[4]Each value is the average of 10 samples.
[5]Summed for 6 minutes per mg. of total nitrogen in the juice.

Tubers from the control and from the 2,4-D, maleic hydrazide and minor element treatment were compared as to their minor element concentration, but little difference was found so the results are not listed. The 2,4-D, maleic hydrazide and minor element treatment produced a marked increase in the free amino acid, proline, over the control and all other treatments.

Table 1 shows the yield, total nitrogen, catalase activity, sprouting data and differences from the control.

The experiment was a randomized design in one direction. A variance analysis was used to interpret results. Significant differences, although biased, are shown. The increases in yiel[illegible] were considerable, but they failed to show significance, possibly because of the high variability within treatments.

Each of the 2,4-D treatments reduced the total nitrogen present in the tuber juice except that the combination of 2,4-D plus maleic hydrazide increased the total nitrogen. The reduction in nitrogen caused by 2,4-D spray was significant at the 5 per cent point. The increase in nitrogen shown for the 2,4-D plus maleic hydrazide treatment was significant at the 1 per cent point.

There is some indication that the activity of the catalase is inversely proportional to the rate of growth of the plant (1), (2) and (4). The activity of the catalase was measured in a Warburg respirometer by its action on hydrogen peroxide. The arbitrary units chosen were microliters of oxygen consumed for 6 minutes per milligram of total nitrogen per milliliter of juice. In every treatment the catalase activity was significantly reduced indicating a possible increase in rate of growth. This trend was also reflected in the yield data.

The treatment containing maleic hydrazide significantly reduced sprouting, but an even greater reduction was produced by the 2,4-D spray. Previous tests on the same area have shown no sprout inhibition due to 2,-4D when used at rates not over ½ pound acid equivalent per acre. The addition of minor elements apparently increased sprouting in the 2,4-D treatments.

With the exception of the sprouting data, nearly all of the differences found could be attributed to the direct or interacting effects of the 2,4-D and maleic hydrazide.

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DENSITY OF POTATO STARCH[1, 2]

D. R. ISLEIB[3]

Inquiry into specific gravity relationships in potato tubers led to speculation that differences in starch density among potato varieties may have contributed to differences in specific gravity between the varieties. The present study was designed to investigate this hypothesis.

EXPERIMENTAL

Starch was obtained from potatoes grown in the 1955 Michigan potato variety trials. Tubers from these trials were exhaustively studied by Sharma (1) and Sharma and Thompson (2), and collateral information on starch grain sizes was available from their work. The eight varieties chosen for this study represented wide divergence in characteristic starch grain size, and in specific gravity. Three lots of each variety were utilized, each lot representing a different location. Therefore one sample was grown in Menominee County in the Upper Peninsula, one in Emmet County at the northern tip of the Lower Peninsula, and one in Allegan County in the southwest Lower Peninsula. The trial in Allegan County was conducted on organic soil, and the other two trials were conducted on light mineral soils. The yield of the Emmet County trial was depressed by extreme drought, but the two other trials yielded normal crops.

Six medium-sized tubers were selected at random from a composite sample representing the four replications of each variety from each location. The tubers were pared, cut into small pieces, and ground in 95 per cent ethanol in a Waring blendor for two minutes. The starch was separated by sieving, followed by sedimentation, and was then washed several times in distilled water. It was dried in a warm drying oven and stored in screw-cap bottles until used.

A single determination of starch density was made on each sample. One and one-half to four and one-half grams of starch were weighted to 0.1 mg. in 10 ml. picnometers and density calculated in the usual way. Where a single sample was in poor agreement with other samples of the same variety additional determinations were made. The data are shown in table 1.

DISCUSSION AND CONCLUSION

Densities of the various samples ranged from a high of 1.575 to a low of 1.503. In general, they were closely grouped around the 1.54—1.55 level, and there was little if any consistent difference among the samples. An analysis of variance of the data indicated a lack of statistical significance in differences between the variety means. Apparently the density of starch from samples of eight varieties grown during 1954 did not differ more than the expected sampling limits, despite the selection of varieties representing extremes in specific gravity and starch grain size.

[1]Accepted for publication November 12, 1957.
[2]Journal Article Number 2152, Michigan Agricultural Experiment Station, East Lansing, Mich.
[3]Assistant Professor, Department of Farm Crops, Michigan State University, East Lansing, Mich.

Sharma (1) found that the density of starch from Cherokee potatoes increased as the size of the grains increased, from a low of 1.531 for grains less than 30 microns in greater diameter to 1.579 for grains above 60 microns in diameter. The density of the intermediate group, 30 to 60 microns in diameter, was 1.556, which agrees with the mean of the three Cherokee samples investigated in this study. This relationship does not seem to be carried over in the comparison of starch densities among varieties with characteristically large and small starch grains.

TABLE 1.—*Starch grain size, starch density and specific gravity of tubers from eight potato varieties grown at three locations in Michigan during 1955.*

Variety	Starch Grain Size	Tubers Specific Gravity	Starch Density			Mean
			Allegan County	Emmet County	Menom. County	
Osage	Large	1.064	1.548	1.550	1.552	1.550
Merrimack	Large	1.074	....	1.515	1.557	1.536
Cherokee	Large	1.067	1.578	1.516	1.575	1.556
Early Gem	Small	1.053	1.544	1.550	1.503	1.532
Ia 961-1	Small	1.067	1.558	1.533	1.522	1.538
Red LaSoda	Small	1.061	1.548	1.538	1.561	1.549
Waseca	Small	1.053	1.534	1.544	1.545	1.541
Tawa	Intermediate	1.064	1.550	1.550	1.556	1.552

SUMMARY

The density of starch from samples of eight potato varieties grown at three locations in Michigan was determined. Despite the wide divergence in specific gravity and starch grain size of the varieties investigated, no significant differences between densities of the starch samples were found.

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NEWS AND REVIEWS

A Review of
ABNORMALITIES IN THE POTATO DUE TO WATER UPTAKE AND TRANSLOCATION[1,2]

WALTER C. SPARKS[3]

Abnormal development of potato tubers has been attributed to various factors, such as soil fertility, soil moisture, spacing, and stem population. For this review, only the problem of tuber malformations as influenced by soil moisture and water uptake and translocation will be discussed.

Most malformed tubers develop into what is known as "second growth" and may assume one of two types, Nielson and Sparks (34). One type, known as "knobby," consists of a secondary lateral growth in which a few eyes of the tuber continue to grow, forming protuberances, or in some cases new tubers, on top of the first one (Figure 1). The second type, known as "off-type" tubers, is caused by secondary longitudinal growth.

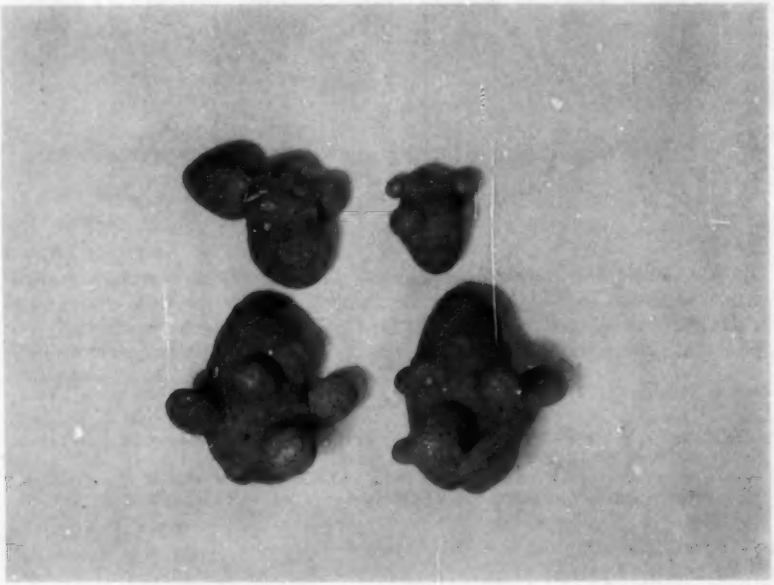

FIGURE 1.—"Knobby" tubers caused by secondary lateral growth.

These tubers have shapes described as bottlenecks, dumbbells, and pointed-ends (Figure 2).

[1]Accepted for publication November 15, 1957.
[2]Published with approval of the Director of the Idaho Agricultural Experiment Station, as research paper number 439.
[3]Horticulturist, University of Idaho Agricultural Experiment Station, Aberdeen, Idaho.

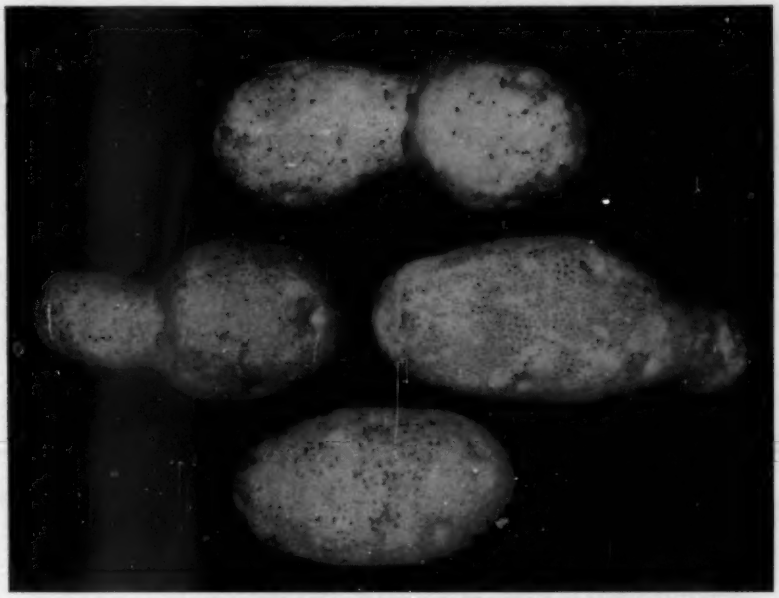

FIGURE 2.—"Off type" tubers caused by secondary longitudinal growth.

Some potato varieties, especially those having long tubers, are more inclined to second growth than others Clarke and Lombard (9); Edmundson, Schaal, and Landis, (20); Hardenburg, (22); Sparks, (40). Werner *et al.* (45) in Nebraska, found that off-type tubers in the round Triumph variety constituted 11.8 per cent of an entire 10-year crop. In contrast to this, Sparks (40) in Idaho, found 53.9 per cent off-type and knobby tubers in the Russet Burbank variety in 1951. Libeau (30) found that malformed tubers were the most important single group of defects among the U. S. No. 2 potatoes in Idaho. This is of considerable economic importance to potato growers in Idaho and Washington where approximately 1,375,000 tons of Russet Burbank potatoes are produced yearly.

Second growth was associated for many years with droughty soil conditions during tuber enlargement Gilbert, (21); Clark, (8); and Stuart, (42). Since these early reports a number of factors have been reported as primary causes of second growth on tubers in various potato varieties. Most of these reports are based on observational data, but agree that drought is the pre-disposing factor Penman (35); Bushnell, (6); Porter, (36), Claypool and Morris, (10); Metzger, (31); Kelley, *et al.*, (23); Murphy, (32); Bennett, (1); Decker, Elmer, and Dean, (17); Werner, Kiesselbach, and Gross, (45); Hardenburg, (22); and Edmundson, Schaal, and Landis, (20). None of these workers distinguished between the two types of second growth, but merely pointed out that these abnormalities were the result of uneven growing conditions caused primarily by drought or uneven soil moisture.

More recent investigations in Idaho by Nielsen and Sparks (34), Corey (12), and Corey and Myers (13) have shown that uneven soil moisture causes an increase in the pointed-end type of secondary growth, but does not necessarily cause an increase in the knobby type of abnormality. In fact, Kraus (25); Corey (12), and Corey and Myers (13) showed that in certain instances uniform irrigation of the Russet Burbank variety of potato actually increased the incidence of knobs. Laferriere (28) found that regular and irregular moisture levels did not seem to affect the incidence of knobby second growth in greenhouse tests. He stated that potato plants grown with roots extending into the water produced knobby tubers, whereas, some plants grown with roots subjected to severe wilting did not produce abnormal tubers of any type.

Moisture may not be the direct cause of knobby second growth, but in field studies it seemed to be an indirect or inter-related cause. This was shown by the fact that increasing the space between plants and, thus, also the area of soil from which each plant draws moisture, increased the percentage of knobby tubers Claypool and Morris, (10); Chucka *et al.*, (7); Sparks, (39); and Rieman, Cooper, and Rominsky, (38). Kraus (24) and Corey (12) have indicated that once a knob was initiated, increasing the amount of available water tended to increase its development. Kraus (25), Nielsen (33), and Laferriere (28) showed that in Idaho reducing the number of stems per hill or per acre increased the percentage of knobby tubers. Here again the amount of space per stem seemed to be the important factor. Krijthe (27) explained this situation in the Netherlands on the basis that the moisture content of the soil was not the only important factor here, but that the proportion of the quantity of moisture evaporated from the plant to the quantity of moisture assimilated by the roots probably also had a great influence. He stated that by removing rows of plants next to the plants which later exhibited secondary tuber growth, evaporation from the surviving plants increased. Simultaneously, assimilation of moisture by the roots decreased, probably owing to the fact that some roots had been damaged by removal of the adjoining rows. At the same time it was possible for the soil around the remaining plants to lose more moisture through evaporation. It appeared that under these circumstances the secondary tuber formation was stimulated.

Spacing may not only increase the amount of water per plant, but it is also possible that increasing the space between plants may increase the light intensity and temperature of individual leaves or plants. Waggoner and Shaw (44) in Connecticut found that exposed leaves of potato and tomato plants were 53.6° F. warmer than shaded leaves. They concluded that the daily mean temperature of open-spaced plants is higher than that of close-spaced plants. Laferriere (28) in Idaho found that shading potato plants significantly reduced knobby second growth. He stated that temperature alone may have a direct effect on the incidence of knobby second growth. He found that some knobby tubers from greenhouse tests sprouted 3 days after being harvested. From this he concluded that a growth regulator usually present in mature tubers is not present in tubers which have heat-sprouted. LeClerg and Henderson (29) working in Louisiana reported that heat-sprouting (the growth of potato tuber buds prior to harvest) was assumed to be due to a combination of high soil temperature and low soil moisture.

Corey and Myers (13) showed that the short-frequency irrigation treatments not only produced a significantly cooler soil temperature than the long-frequency treatment but also produced a higher percentage of smooth tubers.

This poses the question as to which soil moisture percentage will produce the best crop of potatoes. There has been considerable controversy over the years regarding the proper time to begin irrigating potatoes and also how often to irrigate during the growing season. Bradley and Pratt (4) and Bradley and Pratt (5) state that in upstate New York, potato yields were higher when irrigated before the available moisture dropped much below 50 per cent of soil capacity. Cykler (14) in Wyoming showed that in greenhouse trials, best yields were obtained by keeping the water content of the soil at a high level throughout the irrigating season. He stated that the moisture content should not be allowed to fall below one-half the difference between the moisture content at field capacity and the permanent wilting point. He stated (15, 16) that in field trials, high yields and high quality were obtained when a medium moisture level was maintained to a depth of 3 feet, and that the moisture percentage should never be reduced below ⅔ of the way from field capacity to permanent wilting percentage. Pratt *et al.* (37) found that in only one location and one year in up state New York did irrigation result in a significant increase in the quantity of growth defects (growth cracks, second growth, and misshapen tubers). They stated that the 15-bushel-per-acre increase in growth defects was offset by a 64-bushel-per-acre increase in tubers over 2 inches in diameter as a result of the irrigation.

In contrast to these results Blake, Brill, and Campbell (2) indicate that potato yields in Sassafras loam in New Jersey were equally good when available soil moisture was depleted 33 and 67 per cent before irrigation. A possible explanation for these varied results may be indicated by the results of some of the Idaho workers. Nielsen and Sparks (34) found that under Idaho conditions and practices, most of the pointed-end, bottle neck, and dumbbell type tubers could be eliminated by starting the irrigation schedule 30 to 40 days after planting. They state the drought treatment did not alter the total yield, but emphasized that the yield of U. S. No. 1 grade was greatly reduced. They conclude that drought caused by withholding early irrigation water, or planting potatoes early with no advance of the initial irrigation date will increase the production of malformed tubers. These results are borne out by the later studies of Corey and Myers (13). They showed that neither frequency of irrigation nor total water applied had a significant effect on total potato yield. They found, however, that applying water, only when plants showed drought symptoms, caused a great many pointed-end tubers and greatly reduced the yield of U. S. No. 1 tubers.

Since the farmer makes his money on U. S. No. 1 tubers, not on No. 2's or culls, any treatment that results in the highest yield of U. S. No. 1 tubers per acre is the one to practice. Using this criterion, Corey and Myers (13) showed that many more smooth tubers were formed by maintaining the available moisture above 70 per cent.

The fact that many abnormalities arise, even when there appears to be sufficient soil moisture, may be due to the inability of the plants to assimilate and translocate water and manufactured food materials properly. Laferriere

(28) found that mechanical girdling or girdling by Rhizoctonia significantly increased the incidence of knobby second growth. Blodgett and Rich (3) state that Rhizoctonia may girdle the stolon or roots, causing poor stands and single-stem plants which may cause tubers to be small and rough, or large and knobby. Werner *et al.* (44) indicated that Rhizoctonia reduced the number of stems, thus affecting both yield and grade. He also pointed out that the highest percentage of Rhizoctonia, scab, and grade defects occurred in the years of highest yields. Laferriere (28) states that in his greenhouse trials only 5 hills in 50 produced knobby tubers and all of these were girdled by Rhizoctonia. From this it appears that the translocation of water or food had been impaired, resulting in an increase in the percentage of knobby tubers formed.

Dietz and Verner (18) have shown that the growth of potato tubers is not even. Therefore, if an interruption in tuber growth does cause the formation of knobs, how long and under what conditions must a tuber cease growing before knobs are initiated? As previously mentioned, an interruption in water uptake or in water or food translocation by girdling increases the percentage of knobs. Other evidence that the translocation of food or water may play a big part in the formation of knobs is shown by the work on defoliation. Kraus (25), Nielsen and Sparks (34), and Laferriere (28) show that defoliation at certain stages of growth decreased the percentage of knobby tubers formed. Takatori, Sparks, and Woodbury (43) show that in 1951 defoliation late in the season (August 7) decreased the percentage of both off-type and knobby tubers, but defoliation when the plants were beginning to bloom increased the percentage of knobby as well as off-type tubers. Sparks, Woodbury, and Takatori (41) also show that, in 1954, defoliation when the plants were 50 per cent or 100 per cent in bloom increased the percentage of malformed and knobby tubers (U. S. No. 2), whereas, defoliation when the plants were 50 per cent past full bloom decreased the percentage of U. S. No. 2 tubers. This indicated that the stage of growth at the time of defoliation is very important in the production of off-type and knobby tubers. This is borne out by Nielsen and Sparks (34) who state that partial defoliation of plants during early tuber growth will induce the development of malformed tubers. Since the defoliated plants produced tubers having the same malformations as those subjected to drought, it might be inferred that defoliation interfered with water uptake and water and food translocation.

The data cited in this review seem to indicate that uneven growth caused by moisture alone was definitely not the only or primary cause of knobby second growth, but that moisture may be one of the inter-related causes. Mechanical girdling or girdling by Rhizoctonia significantly increased the incidence of knobby second growth. Shading of potato plants significantly reduced knobby second growth. Water uptake and translocation are the most important factors governing uneven growth. Uneven growth is the primary cause of off-type tubers of the pointed-end, bottleneck and dumbbell shapes.

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THE BEGINNING OF SEED POTATO CERTIFICATION IN HIMACHAL PRADASH INDIA[1]

A. R. CHAUHAN[2]

The important locality of seed potato production in India is the Mahasu District of Himachal Pradash Territory. This District, comparable in size to a large American county, lies in the foot-hills of the Himalaya Mountains. Although only 30° to 32° latitude North (like southern Louisiana) at elevations above 5000 feet the summer climate is suitable for potatoes. Simla is the principal town from which seed is shipped.

This district had gained recognition for good seed potatoes prior to the independence of India in 1947. Independence was followed by internal political reorganization. The Territory of Himachal Pradash was a consolidation of 36 former states. By 1949 its provisional government was operating. A program to aid and encourage agriculture was promptly initiated. As one phase of this program, plans were made for certification of seed potatoes.

Instead of attempting to inspect potatoes being grown for seed in 1950, the Government began producing foundation stock at a newly acquired Shilaroo Government Farm in Mahasu District. The initial stock was the variety Up-to-Date, obtained from the Central Potato Research Institute. Dr. Pushkar Nath, then Botanist, now Director of the Institute, accepted part-time assignment as Development Advisor for the certification of seed potatoes. As a whole the program was directed by the Potato Development Officer of the State and the Director of Agriculture.

By 1952 Shilaroo Farm was in a position to distribute foundation seed potatoes to registered applicants.

By 1954 some seed was certified for sale, and as hoped, the volume has increased, as shown in table 1.

It was also gratifying that during these years the reputation of Mahasu uncertified seed was well maintained as indicated by a surprising increase in volume, also shown in table 1.

TABLE 1—*Seed Shipped from Mahasu District*

Year	Certified	Uncertified	
	Bushels	Acres	Bushels
1950	....	25,691	237,301
1951	....	41,875	308,191
1952	....	69,204	597,827
1953	....	89,909	879,828
1954	28,981	97,888	1,009,987
1955	102,834	109,723	1,385,957
1956	287,833	139,543	1,883,991

[1]Accepted for publication, November 24, 1957.

[2]Block Development Officer, Karsog, Himachal Pradash, India. Currently, Graduate Student, Department of Horticulture, Ohio State University, Columbus, Ohio.

Advisory and Inspection Service

Agricultural advisory service in the Territory is disseminated through Agriculture Inspectors and Government Farms situated about ten miles apart. Where potatoes are grown for seed, each Government Farm has a Potato Technical Assistant who operates a spraying service, gives on-the-spot advice on roguing, and other problems, and then functions as Inspector of fields entered for certification. His work is supervised by an Agricultural Inspector, located at the Block Headquarters. At the Regional Headquarters is the Regional Potato Development Officer.

During marketing season, few trained inspectors are deputed from other places temporarily to watch the potato belts so that damaged seed may not be bagged. They check all the potatoes in sale depots once a day and no seed can be transported unless it is checked and stamped properly. The consignments are finally checked at Simla the rail head before moving by freight.

Cultural Methods

Farming methods are primitive. At elevation suitable for growing seed potatoes, most of the land is rough or hilly. Farms are small, averaging perhaps 10 acres. Plowing is done with oxen. Planting is in March or early April. Seed is dropped in alternate furrows, the plowman dropping one seed piece at each step. Ten to 15 maunds of seed are sown per acre (a maund is 82 pounds). Weeding and roguing is done by hand with a special type of spade. Both weeds and rogues are hauled from the field. As a rule, fields are thus rogued twice.

As yet, most farmers are not conversant with specific diseases. They simply remove plants which appear to them in any way abnormal. After two roguings, the Potato Technical Assistant may advise some further work. Because he operates the spraying service, the Potato Technical Assistant keeps well informed on the prevalence of insects and diseases, and can call upon his Supervisors for assistance if an epidemic threatens.

Harvesting starts in late September, after a tropical rainy season extending from July into September. The potatoes are plowed out with oxen, and are picked up into baskets.

GRADING

In general there are three different grades and the potato bags are tied with distinguishing colored jute strings.

S. N.	Grade	Color of Jute String
1.	Special (large)	Red
2.	Phool (medium)	Dark Blue
3.	Ration (small)	Light Blue

Grading is much the same as in the United States of America except that the emphasis mostly is placed on the sizes and they have no rigid specifications.

Grade Inspectors are located at marketing centers and all the grades are checked by them. All seed potatoes, certified or uncertified, carry a grade inspectors stamp.

Sales Organization

The business formerly was monopolized by the local merchants (Arthies). They used to dictate their policy, and farmers were being charged sufficient amount as a middleman profit.

Popular Government came into existence and at once handed over the entire business to the Cooperative Societies. The Societies were opened in each Revenue circle, (having a population of 3-6 thousand). The Union of such Societies was made at the county level and on top of that at the District level and Territory level.

The Societies handle the sale for the grower and remit to him the returns for the sale, less a predetermined nominal commission fee.

All the Cooperative Societies are Government sponsored, and are under the strict supervision of the Registrar Cooperative Societies of the Territory administration. The Cooperative Sale Agency principally stores potatoes in government potato storages, which are constructed on the roadside in each County. Potatoes are then shipped from these storages according to the demand of the trading market.

Transport and Time of Shipment

There is scarcity of roads in the interior because of the hard rocky hills. However, the work is in tremendous progress and target will surely be achieved within a short period. At present there are some important highways which extend to nearly 100 miles in the interior and are suitable only for trucks. The seed from the interior of the District is transported on mules and ponies to the roadside and is carried by trucks up to Simla which is a narrow gauge rail head.

It will not be out of place to mention that the whole transport system in the State is nationalized and is owned by the government. It is an item of serious consideration by the government. The efficiency of the transport increases the price for the potato seed, which ultimately benefits the growers.

Shipping starts in October, extending to mid-December when winter sets in and deep snow paralyzes traffic until March. Delivery extends far and wide throughout the nation as shown by figure 1.

Encouragement by the State

The government proceeded paternalistically to improve potato production and has apparently drawn on the long experience of countries like Scotland, both in the requirements for certification and in the development of cooperative storage and selling agencies. To the writer these programs seem highly successful.

The government, however, has two further programs for stimulating seed potato production. First, in offering small tracts of forested land to landless tenants for clearing. These tracts, costing but little, are at high elevations, suitable principally for potatoes. The second stimulant to encourage certification, the government is paying the grower a subsidy of $1.00 for each 164 pound-bag of certified seed produced.

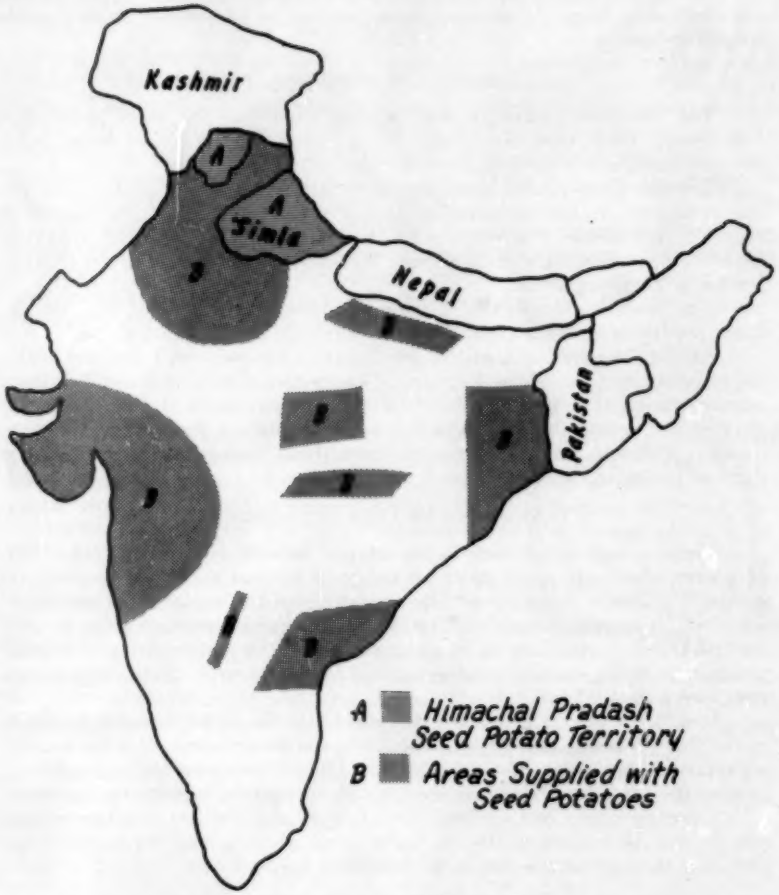

FIGURE 1.—Extent of seed potato delivery from Himachal Pradash.

ABSTRACTS OF PAPERS PRESENTED AT THE FORTY-FIRST ANNUAL MEETING

HADDOCK, JAY L., AND RAY D. JACKSON

SOME PLANT NUTRIENT RELATIONSHIPS IN THE POTATO CROP GROWN ON A CALCAREOUS SOIL

As a help towards clarifying the concept "Optimum Nutritional Status" of potatoes, a study of the chemical composition of tops, tubers, and roots of potatoes grown on a calcareous soil was made. A wide seasonal range in the "quantity factor" and "quality factor" was observed in tops, roots, and tubers. The "quantity factor" decreases rapidly with increase in season for tops, roots, and tubers. Seasonal change in "quality factor" are less striking but of great interest.

HARRINGTON, W. O., R. L. OLSON, W. J. WESTON, AND MARY L. BELOTE

EFFECTS OF PROCESS VARIABLES IN POTATO GRANULE PRODUCTION

Laboratory studies of process variables in production of potato granules by the add-back process are discussed in this paper. Included also are relations of raw material factors to yield and quality of the final product. Higher solids potatoes yielded more and better granules than potatoes of lower solids. Peeling, washing and cooking procedures are discussed in relation to color, texture, and flavor of the product. Quality was shown to depend on the methods of mashing and mixing the cooked potatoes with the add-back granules, and on the temperatures during these operations. Addition of sulfite was found necessary for retention of good product color during dehydration.

HOOKER, W. J., AND A. P. BENSON

TIME OF SYMPTOM RESPONSE IN *DATURA STRAMONIUM* VAR. *TATULA* TO VIRUS X AS A FUNCTION TO VIRUS CONCENTRATION

Serial dilutions of partially purified virus X inoculum were mechanically inocul-ated to *Datura stramonium* var. *tatula* L., and *Gomphrena globosum* L. All plants in each replication were of like age.

Carborundum was added to the inoculum as well as the leaves in order to facilitate maximum infection. Leaves were rubbed an equal number of times using a glass spatula and a paper towel for support.

D. stramonium was more sensitive than *G. globosum* to virus infection. Dilution end point on *Gomphrena* was 10^{-4} producing only 2 lesions on 6 inoculated leaves. Systemic symptoms in *D. stramonium* were developed up to 10^{-6}.

Although the average number of days for symptom development was lower in the higher concentrations, there was no clear cut difference on a plant per plant basis. Rather, more plants developed symptoms in the higher concentrations at an earlier time than at the lower concentration. Occasionally, however, a few plants in the lower concentrations required an abnormally high incubation period for symptom expression, suggesting that symptom development was a function of virus concentration.

HOUGAS, R. W., S. J. POLOQUIN, AND R. W. ROSS

INDUCED HAPLOIDS IN *SOLANUM TUBEROSUM*

Interspecific matings were used as a tool for obtaining haploids of *S. tuberosum*. Ten selections of the commercial potato (2n=48) were used as pistillate parents in matings with 7 diploid selections (2n=24). Stocks with contrasting genetic characters, such as pigmentation and leaf morphology, were selected in order to distinguish the F_1 hybrids from the haploids. Approximately 800 seedlings were obtained from over 6000 pollinations. Twenty-nine haploid plants (2n=24) of *S. tuberosum* were found among these seedlings. Morphologically the haploid plants were smaller than either the F_1 hybrids or the *S. tuberosum* selection from which they originated. These was, however, considerable variation in their morphology, pollen fertility, and meiotic regularity.

HOUGAS, R. W., S. J. PELOQUIN, AND R. W. ROSS

THE POTENTIAL OF HAPLOID POTATOES FOR RESEARCH AND BREEDING

The basic chromosome number of the tuber-bearing Solanums is recognized to be 12 by most investigators. The common potato, *Solanum tuberosum*, has a somatic chromosome number of 48 and is generally considered an autotetraploid species. The difficulties inherent in breeding and genetic study of an autotetraploid are well-known to plant breeders.

Haploid *S. tuberosum* plants (2N=24) have been obtained by the authors through interspecific matings. Such haploid plants may be expected to exhibit disomic, rather than tetrasomic, inheritance and hence will be valuable tools for genetic and cytogenetic study. Matings between the *S. tuberosum* haploids and several tuber-bearing, diploid *Solanum* species have been successful. The success of these matings is of particular interest from the breeding standpoint since it seems to present an expeditious, new approach for gene transfer from the vast reservoir of germ plasm residing in the 50-odd, tuber-bearing, diploid *Solanum* species to the common potato.

HOUGHLAND, G. V. C.

THE INFLUENCE OF PHOSPHORUS ON THE GROWTH AND PHYSIOLOGY OF THE POTATO PLANT

Less than 15 per cent of the phosphorus supplied in the fertilizer is absorbed by the potato crop and only six to seven per cent is removed in the tubers. More than 85 per cent of the phosphorus supplied remains in the soil as residual phosphorus.

An experiment was conducted in the greenhouse using a special solution culture procedure to evaluate the effect of time and amount of phosphorus application on yields while all other essential nutrients were supplied in abundance.

Plants grown without phosphorus for 50 or 70 days showed definite signs of phosphorus deficiency and the length of tuber stolons, their number, and tuber size were all adversely affected. When the phosphorus-deficient plants were supplied with phosphorus, recovery was rapid after 50 days without phosphorus, but after 70 days without phosphorus, recovery was much slower or impossible.

After 80 days the percentage of phosphorus in the plants decreased; however, the amount of phosphorus in the tubers increased. Analyses showed that 74 per cent of the plant phosphorus was in the vines and 26 per cent in the tubers at 50 days and ten per cent in the vines and 90 per cent in the tubers at 112 days.

Where phosphorus was supplied for the first 50 or 70 days and thereafter withheld, the plants absorbed sufficient phosphorus for normal tuber development.

Because the potato plant has a critical need for an abundant supply of available phosphorus early, for vine growth and tuber development yield responses can be expected from phosphorus applications to potato soils high in residual phosphorus.

The relation between plant phosphorus supply and tuber development emphasizes the fundamental importance of plant phosphorus in the conversion of carbohydrates, especially in the metabolism of starch. This phase of the problem will be given further study.

HOYMAN, WM. G.

EFFECT OF THIMET ON INCIDENCE OF VIRUS Y AND PURPLE-TOP WILT IN RED PONTIAC POTATOES

The systemic insecticide Thimet, O, O-diethyl S-(ethyl-thiomethyl) phosphorodithioate, was formulated at the rate of 3⅓ lbs. actual in 250 lbs. of 12-12-12 granular fertilizer and applied in bands at this rate per acre at planting of virus-free Red Pontiac seed potatoes. The plot was designed so that rows of ND530, a potato selection carrying virus Y, were planted between and on the outsides of 5 rows of Red Pontiac. The rows were 6 feet apart and 100 feet long, and one-half of each Red Pontiac row received the Thimet fertilizer mixture. The green peach aphid, *Myzus persicae*, an efficient vector of virus Y, was placed on all rows of ND530 June 17 when these and the Red Pontiac plants averaged 8 and 4 inches in height, respectively. *M. persicae* was also placed on all rows of ND530 June 24 and July 3. A natural infestation of the 6-spotted leafhopper, *Macrosteles fascifrons*, a vector of

aster yellows virus, was responsible for the appearance of purple-top wilt. Current-season virus Y and purple-top wilt symptoms were recorded from July 15 through August 21. On the latter date the incidence of virus Y was more and purple-top wilt was less in Red Pontiac plants receiving the Thimet fertilizer mixture than in the non-treated. An analysis of variance showed that this incidence of purple-top wilt was significantly less.

ISLEIB, D. R.

DENSITY OF POTATO STARCH

Density of starch from samples of eight potato varieties grown at three locations in Michigan was determined. Despite the wide divergence in specific gravity and starch grain size of the varieties investigated, no significant differences among densities of the starch samples were found.

ISLEIB, D. R., AND N. R. THOMPSON

TEMPERATURE-GROWTH RELATIONS: II. INFLUENCE OF SOIL TEMPERATURE ON RATE OF ROOT AND SPROUT GROWTH OF POTATOES

Sprout and root growth of potato seed pieces representing ten varieties was studied in the range of 45 to 60° F. The critical temperature for growth was in the 48-50° range. No consistent association between early maturity and rapid seed-piece germination could be detected.

JACKSON RAY D., AND JAY L. HADDOCK

GROWTH AND NUTRIENT UPTAKE OF RUSSET BURBANK POTATOES

Growth and nutrient accumulation data were collected for Russet Burbank potatoes in 1954. Dry weight plotted against time curves for total plant and for tubers were found to be typified by four segments or growth periods. Equations were fitted to the data by the method of least squares using logarithms. Derivatives of these equations evaluated at thirteen sampling dates yielded growth rates which were plotted against time.

MIYAMOTO, T., E. J. WHEELER, AND S. T. DEXTER

STUDIES OF COLOR AND DECAY IN CONDITIONING OF POTATOES FOR POTATO CHIPS

Tubers of the Russet Rural variety were submitted to different relative humidities and modified atmospheres. The potatoes were placed in a storage in late September and held until January 12 at a temperature of 40° F. to assure maximum reducing sugar content as indicated from a frying test. The tubers were placed in sealed metal containers provided with intake and outlet for ventilation. The tubers were subjected for nine weeks at 70° F. temperature, to conditions of dry air, wet air, and 10 per cent CO_2, ventilated and also with the same treatments poorly ventilated. At 3, 5, 7 and 9 weeks the containers were unsealed and notes made on decay of tubers and color of the chips. Decay loss totalled at end of 9 weeks for dry air ventilated was 2.8 per cent, wet air ventilated 100 per cent and 10 per cent CO_2 ventilated 53.5 per cent. The same treatments poorly ventilated showed in dry air 100 per cent decay in 7 weeks, and 96.4 per cent in 5 weeks. In wet air the tubers decayed in 3 weeks. All of the tubers decayed in atmosphere of 10 per cent CO_2 in 5 weeks with 76 per cent decay in 3 weeks.

The chips were scored on the basis of 10 points for the darkest and one for white. The chip color averaged 9.50 for all potatoes at the start. In 7 weeks the following chip colors were observed: Dry air ventilated 3.05; wet air ventilated 6.10; and 10 per cent CO_2 ventilated 6.80. All of the tubers in the poorly ventilated containers had decayed, consequently, no chips were available for scoring.

MURPHY, HUGH J., AND MICHAEL GOVEN

EFFECT OF SOURCE OF POTASH ON RUSSETING OF THE RUSSET BURBANK POTATO IN MAINE

Lack of uniform russeting in Maine-grown Russet Burbank potatoes is a very common external defect which detracts materially from tuber appearance when they are sold for table use.

Studies conducted in 1956 and 1957 at Aroostook Farm, Presque Isle, Maine, indicate that sulfate of potash will produce a higher degree of tuber russeting than will potassium chloride when used as a source of potash in potato fertilizer.

Where sulfate of potash was used as the source of potassium, 82 per cent of the tubers had more than 25 per cent of their surface area russeted, as compared with only 48 per cent of the tubers russetted where potassium chloride was used.

The use of sulfate of potash in potato fertilizers when growing Russet Burbanks', plus certain other cultural practices, may produce a more acceptable Russet Burbank for table use.

PERRY, ALVAH L.

CONSUMER ACCEPTANCE OF U. S. FANCY GRADE POTATOES

Retail customers at eight supermarkets in the Boston Market area were given an opportunity to buy U. S. Fancy grade Maine potatoes. These potatoes were washed, Katahdin potatoes, 2½ to 3¼ inches in size and packed in 10-pound polyethylene bags. They were sold in competition with potatoes regularly carried by the stores.

At a premium of 30 cents a 10-pound bag over the price of regular U. S. No. 1 grade unwashed Maine potatoes, sales of the U. S. Fancy grade amounted to 18 per cent of the total volume of potato sales. When the premium on this pack was dropped to 10 cents a package, the sales of the U. S. Fancy potatoes averaged 29.8 per cent of the potato sales.

RIEMAN, G. H.

EFFECT OF GAMMA-RAY IRRADIATION OF POTATO POLLEN ON SEED PRODUCTION

A 400 curie cobalt-60 source was used to radiate freshly extracted potato pollen at three dosage levels. The average number of seeds per seed ball resulting from pollinations with irradiated pollen ranged from 7 for the 20,000 r, 555 for the 10,000 r and 86 for the 1,000 r dosages. The control pollinations produced an average of 212 seeds per seed ball. The seed samples from the 1,000 r treatments appeared to be normal, while the seed samples from the 10,000 r and 20,000 r treatments contained more than an average amount of small or aborted seed.

ROBINSON D. B., R. H. LARSON, AND J. G. WALKER

VERTICILLIUM WILT OF POTATO

Isolates of the fungus from potato, collected from widely scattered areas in the United States and Canada, were found to be of two distinct morphological types, identifiable by the formation in culture of pseudosclerotia (PS) or darkened resting mycelium (DM), respectively.

Dark mycelial isolates had lower temperature maxima for both growth and pathogenicity, and were more pathogenic on potato and tomato than were the pseudosclerotial forms. Mixed inocula could be separated, *in vivo*, into the two component types, by suitable variety-temperature combinations.

Monospore analysis of an isolate of each type yielded forms common to both, but the bulk of the monoconidial lines were similar to the "wild" parent. Ultraviolet irradiation of a monospore culture of each type gave an array of morphological variants, but with no reversion of one type to the other. These mutants were, in general, less pathogenic than the parent forms.

Resistant potato varieties were frequently found to be symptomless hosts of these *Verticillia*. *Verticillium albo-atrum* was found to progress steadily throughout the

plant during the growing season, and to continue its advance through tubers of a susceptible variety during winter storage.

Stem streaking and a severe tuber lesioning were shown to be associated with *Verticillium* infection. Stem streak was encountered only in the varieties Irish Cobbler and Sebago, and was found to be the result of extensive permeation of the plant by the fungus under conditions of high soil moisture and fertility. The extent of tuber lesioning, or brown eye, was correlated directly with the incidence of wilt and was very destructive in some varieties. Seed treatment gave good control of both disorders in the variety Kennebec. Evidence was obtained that tuber lesions were incited by a *Pseudomonas* bacterium.

The present study provides evidence in support of the view that, in culture, isolates of Verticillium from potato that form pseudosclerotia are *Verticillium dahliae* Kleb., and that those forming only dark mycelia are *Verticillium albo-atrum* R. and B.

SAWYER, R. L.

NITROGEN FERTILIZATION OF POTATOES

Considerable economic advantage can be gained by manipulating the nitrogen fertilization of potatoes. A 6-24-24 or a 5-10-10 ratio fertilizer can be used at planting to furnish the necessary P and K. Nitrogen can be brought up to the desired level at come-up or the 6 to 8 inch plant stage using the least expensive forms of nitrogen. As long as potatoes receive 70 pounds of nitrogen at planting time there is no detrimental effect on maturity, yield, black spot, sprouting or shrinkage. Quality as measured by specific gravity tends to be lower with the 4 to 6 inch supplemental application of nitrogen than the "come up" application.

SAWYER, R. L.

TIMING OF MALEIC HYDRAZIDE SPRAYS TO STAGE OF PLANT DEVELOPMENT

Maleic hydrazide had given inconsistent results on Long Island when using the timing methods based on number of days before harvest or vine killing. Consistent effective sprout control was obtained by the use of the blossom fall stage of plant development as a spray date. This held true when potatoes were planted in early April or late May. Sprays at full bloom or earlier, can cause heavy yield reduction. The blossom fall application gave no detrimental effects to yield, specific gravity, black spot, peeled discoloration or chipping quality of Katahdin tubers.

SCHAAL, LAWRENCE A., AND CLARK H. LIVINGSTON

EXPERIMENTS ON THE USE OF PENTACHLORONITROBENZENE (PCNB) AS A CONTROL FOR POTATO SCAB AND RHIZOCTONIA

In 1955 experiments to determine the rates of applying PCNB to the soil for the control of scab were conducted in the San Luis Valley of Colorado. These studies were continued in 1956 to evaluate this material as a control measure against scab as well as *Rhizoctonia solani* causing stem lesions. In 1955 applications of the 20 per cent PCNB dust were made with a 35 inch fertilizer spreader at 25, 50 and 100 pounds per acre of active ingredient. The PCNB which had been applied as a broadcast application was double disked into the soil just prior to planting. No phytotoxicity was noted at any level used. The 50 and 100 pound rates reduced scab incidence whereas the 25 pound rate failed to reduce scab sufficiently to be of commercial value. The 1956 tests to determine rates as well as methods of application were conducted on two farms in the same area as the 1955 studies. One test was established on the same field that received the 100 pound rate in 1955 to test the carryover effect. The 20 per cent PCNB dust applications made in 1956 were blended with finish-grade vermiculite to facilitate spreading. Following broadcast application, the dust was rototilled into the soil. Twelve inch in-the-row band applications were also rototilled and other band applications were made and the potatoes planted through the band depending upon the planter discs to incorporate the dust into the soil. Notes on stem lesions caused by *Rhizoctonia solani* were made in 1956

when the plants were 12 to 14 inches high. Soil treatment with PCNB at the 50 and 100 pounds per acre level did not decrease the incidence of either stem lesions caused by Rhizoctonia or scab. Likewise methods of application had no effect in the 1956 tests and there was on apparent carryover effect of the 100 pounds per acre rate applied in 1955. The 1956 season was extremely dry and the plants were therefore grown under adverse soil moisture conditions. It appears that dry soil and vermiculite may have rendered the PCNB ineffective as a control measure for scab and stem lesions caused by *Rhizoctonia solani*.

SMITH, ORA

POTATO QUALITY X. POST HARVEST TREATMENTS TO PREVENT AFTER COOKING DARKENING

Liquid or gaseous treatments of whole unpeeled potato with sulfur dioxide, sodium gluconate, sodium bisulfite, sodium acid pyrophosphate and several chelating agents of the EDTA and HEDTA groups have been found to reduce or prevent after cooking darkening in potatoes.

SMITH, ORA

POTATO QUALITY XI. PREVENTING THE BROWNING REACTION IN POTATO CHIPS.

Freshly harvested potatoes were treated with sulfur dioxide gas before the accumulation of reducing sugars. When treated potatoes were placed at 40° or 50° F sugar accumulation was retarded or prevented. This resulted in light colored chips being made from these potatoes for a period of 6 weeks at 40° and longer when stored at 50°F. Untreated potatoes accumulated large amounts of reducing sugars within 2 weeks storage at 40° and resulted in chips that were much too dark to be acceptable.

SMITH, ORA

POTATO QUALITY XII. IMPROVING SKIN COLOR OF WHITE POTATOES

Treatment of white skinned potatoes with sulfur dioxide gas for short periods brightened the skin color of newly harvested Sebagos and of Katahdins which had been in 40° storage for 10 months.

SMITH, W. L., JR.

SUBERIN AND PERIDERM FORMATION AND DECAY OF POTATO SLICES AS AFFECTED BY LENGTH OF TUBER STORAGE

Eight varieties of potatoes were stored at 40° F. for various periods. Slices from these tubers shortly after harvest and after 2½, 4½, and 6½ months were held in moist chambers at 70° for 1, 2, 3, and 4 days and then examined for the development of suberin and periderm. Usually the greatest development took place shortly after harvest. Formation of these barriers definitely decreased after 2½ months' storage and did not appreciably change with longer storage. Inoculation of the slices with *Erwinia atroseptica* after the different periods at 70° showed that bacterial decay and barrier formation were negatively correlated.

THOMPSON, N. R., AND D. R. ISLEIB

SPROUT INHIBITION OF BULK-STORED POTATOES

Sprouting of 10,000 bushels of Katahdin potatoes was checked satisfactorily on May 8, 1957, by the introduction of methyl ester of naphthalene-acetic acid into the air circulation system of the storage.

THOMPSON N. R., AND D. R. ISLEIB

TEMPERATURE-GROWTH RELATIONS: III INFLUENCE OF MATURATION TEMPERATURE ON CHIPPING QUALITY OF POTATOES

Russet Rural potatoes grown in 12-inch pots for 14 weeks were allowed to mature under normal day temperatures and 4 night temperatures of 65°, 55°, 45° and 38° F. At maturity potatoes were: (1) harvested and samples were chipped; (2) placed in 38° F. storage for 10 weeks, chipped; (3) conditioned at 75° F. for 6 weeks and chipped.

Tubers maturing at night temperatures of 65° and 55° F. made acceptable chips at harvest time and conditioned satisfactorily. Tubers maturing at night temperatures of 45° and 38° F. made very dark chips at harvest time and failed to condition. All samples cooked dark when stored for 10 weeks at 38° F.

The color of all samples of chips showed the same color gradient in relation to night maturation temperatures at harvest, when stored, and when conditioned.

UMAERUS, VILHELM

THE RELATIONSHIP OF PEROXIDASE ACTIVITY IN POTATO LEAVES AND RESISTANCE TO *PHYTOPHTHORA INFESTANS*

A positive correlation was found between peroxidase activity and field resistance of *P. infestans* in varieties of *S. tuberosum*. The peroxidase activity increased with age of leaves, higher light intensity and virus infection; indications are that field resistance follows the same pattern. Such a correlation was not found in *S. demissum* x *S. tuberosum* hybrids screened for field resistance in Mexico. For several reasons it is suggested that field resistance as found in *S. demissum* and its derivatives might be a resistance to infection, *e.g.* to penetration by a spore, whereas field resistance as found in *S. tuberosum* is a resistance to a spread of the fungus in the leaf tissue.

WARE, L. M., AND W. A. JOHNSON

EFFECT OF DIFFERENT CULTURAL PRACTICES ON YIELD OF POTATOES IN ALABAMA

Independent and joint effects of irrigation (I), fertilizer rates (F), organic materials (O), spacing of seed (Sp), and size of seed (S) were measured over a 3-year period. Treatments were arranged in a 3 x 2 x 2 x 2 x 2 factorial design with four replications. Increases in yield at the .05 or .01 level of significance were obtained over the 3-year period for each of the separated treatments and for joint treatments as follows: I x F, I x O, I x Sp, I x S, F x Sp, O x Sp, O x S, Sp x S, I x F x Sp, and O x Sp x S.

The 3-year average yield increase in 100-pound bags per acre from irrigation was 51.1, from fertilizer rates 35.0, from organic materials 30.9, from closer spacing 13.6, and from larger seed 19.0. Increases in yield from joint use of treatments over some of the separate treatments were 38.7 bags for irrigation and organic materials; 32.8 bags for irrigation and higher fertilizer rates; 12.1 bags for irrigation and closer spacing; 11.5 bags for higher fertilizer rates and closer spacing; 9.8 bags for organic materials and closer spacing; 12.3 for organic materials and larger seed; 9.2 bags for closer spacing and larger seed; 21.1 bags for irrigation, higher fertilizer rates, and organic materials; 29.4 bags for irrigation, higher fertilizer rate, and closer spacing; and 19.3 for organic materials, closer spacing, and larger seed.

In the very dry season of 1956, irrigation increased yields 103.8 bags, organic materials 31.2 bags, and higher fertilizer rates 29.1 bags per acre, but the joint effects of irrigation and higher fertilizer rates accounted for 49.9 bags, and of irrigation and organic materials for 48.2 bags per acre more than the separate effects of the respective treatments.

Irrigation consisted of 1 inch per week when rain did not supply that amount; fertilizer rates were 800, 1,600, and 2,400 pounds per acre of a 6-10-7 grade; organic material consisted of 6 tons per acre of green crotolaria added in summer and 2 tons of dry lespedeza added in winter; spacings were 24 and 12 inches; and seed piece sizes were ¾ and 1½ ounces.

WEBB, R. E., AND E. S. SCHULTZ

EVALUATING POTATO SELECTIONS FOR RESISTANCE TO POTATO VIRUS A

Potato clones selected from parents possessing resistance to virus A were grown in the greenhouse in 3-hill lots, and each plant was approach-grafted with a virus-A-infected plant of potato seedling 41956 (immune from virus X). Selections which showed a top-necrotic reaction, a type of field immunity, were eliminated from further testing. About 30 days after grafting, the remaining selections were subinoculated to the virus-A-indicator plant, *Solanum demissum* Lindl. P.I. 175404. These inoculations were made with a compound leaf from each grafted plant. The leaves were rolled around a pair of tweezers, macerated on a sterilized putty knife and rubbed on leaves of the indicator host. Small bluish-black local lesions developed on the indicator plants 4 to 6 days after inoculation with material from susceptible selections. Selections susceptible to virus A by grafting were again planted in 3-hill lots to determine which of these were immune from aphid infection with virus A (a second type of field immunity). When the plants were 1 to 2 inches high, 25 to 50 virus-A-infective aphids, *Myzus persicae* (Sulz.), were placed on them. The plants were then enclosed in a ventilated pliofilm cage and after 24 hours the aphids were killed with an insecticide. After an incubation period of 30 to 35 days, diagnosis of infection was made by subinoculating from each plant to the indicator host. Results during a 3-year period have proved this procedure to be feasible and highly effective for determining potato selections that are field immune from virus A. It eliminates all field testing and reduces substantially the amount of greenhouse space previously required for this work.

WEBB, R. E., AND E. S. SCHULTZ

TRANSMISSION AND PHYSICAL PROPERTIES OF A VIRUS ISOLATED FROM PLANTS GROWN FROM CORKY RINGSPOT-AFFECTED TUBERS

A small percentage of the plants grown from Sebago tubers affected by corky ringspot were severely dwarfed. Some of the stems of apparently healthy and dwarfed plants were also affected with necrotic streaking. In addition, leaves of the dwarfed plants were malformed, mottled, and some showed irregular necrotic spotting. Some tubers of the diseased plants developed necrotic symptoms similar to those observed on and in the parent tubers. Transmission of a virus from Sebago plants to healthy plants of seedling 41956, Sebago, and Katahdin was occasionally accomplished by inoculation with healthy leaf tissue mascerated in a 5M sodium phosphate buffer. Local necrotic spotting usually occurred on the inoculated leaves of infected plants of Sebago and Katahdin in 7 to 8 days, but only infrequently on seedling 41956. A moderate mottling with slight leaf rugosity and leaf epinasty usually indicated infection of seedling 41956.

Systemic symptoms did not develop in Sebago and Katahdin. The virus was readily transmitted from infected plants of seedling 41956 to healthy plants of *Capsicum frutescens* L., *Datura bernhardii* Lund., *D. metel* L., *D. stramonium* L., *Gomphrena globosa* L., *Nicotiana glutinosa* L., *N. rustica* L., *N. tabacum* L. var. *samsun* and *Solanum demissum* Lindl. All these hosts developed local lesions or necrotic spotting from 5 to 7 days after inoculation. A systemic mottling followed the necrotic reaction in *N. glutinosa* and *N. tabacum*. Necrotic spotting of the leaves accompanied the systemic mottling in *D. bernhardii*, *D. metel*, and *D. stramonium*. Inoculated plants of *G. globosa* and *S. demissum* were killed by the virus. The virus was not transmitted by *Myzus persicae* (Sulz.) to these hosts. The virus contained in the sap from infected plants of seedling 41956 had a dilution end point of 1 to 1,000, a thermal inactivation point between 74° and 76° C. in 10 minutes, and a longevity *in vitro* at 20° C. varying between 8 and 16 days.

YOUNG, DONALD A.

A FUNGUS-LIKE STRUCTURE IN POTATO TUBERS AND POTATO TISSUE CULTURES

The tubers of 60 potato varieties, 185 seedlings and 45 *Solanum* species were surveyed, and a fungus-like structure was present in all tubers examined. A mycelium,

similar to that occurring in tubers, was present in callus tissue cultures derived from the tubers, stems, rhizomes and leaf petioles of the potato plant. Tissue cultures free from the fungus were established by dissecting small groups of cells from established cultures, and in some cases by growing infected cultures on a medium containing antibiotics. Evidence indicates that the organism may be seed-borne within surface sterilized seed. Because of the ever-presence of the fungus in tuber tissue grown under normal conditions, and because of the failure of attempts to separate the fungus from its host, it is possible that the fungus may have entered into a symbiotic, mycorrhiza-like association with the host tissue.

YOUNG, L. C., AND DONALD A. YOUNG

A STUDY OF THE MULTI-GENIC TYPE OF RESISTANCE TO *PHYTOPHTHORA INFESTANS*

A group of 299 seedlings and 16 varieties in a replicated field trial were inoculated with race 1, 3, 4 of the organism using a portable low pressure sprayer. Ninety-four of the seedlings displayed resistance in varying degree. The varieties Hindenburg, Richter's Jubel, U.S.D.A. 96-56, U.S.D.A. 46952 and President appeared frequently in the parentage of the resistant seedlings. Voran was the most resistant variety, with Parnassia, Alpha, President, Noordeling, Ackersegen, Hindenburg and Sebago following in descending order.

In a replicated field trial designed to study the effect of maturity upon resistance, 12 seedlings and varieties were planted on five dates over a period of 40 days. Young plants were more resistant than mature plants of the same variety. As the young plants became more mature they approached the level of susceptibility of the earlier plantings. Resistant varieties showed a narrower range of susceptibility between dates of planting than susceptible varieties. The difficulty of assessing resistance in field plots was emphasized.

A modification in field trials is suggesed. Test varieties should be planted in blocks according to maturity, or preferably, planting should be at different dates, so that all varieties will be at approximately the same stage of physiological development at the time of exposure to the organism.

CALL FOR PAPERS

The 42nd Annual Meeting of the Potato Association of America will be held in conjunction with the A.I.B.S. meeting at Indiana University in Bloomington, Indiana, August 24 through 28. 1958. Other societies meeting at the same time include the American Phytopathological Society, the Mycological Society of America, and the American Society for Horticultural Science.

Please send titles of papers to be presented at this annual meeting to Robert V. Akeley, Crop Research Division, Plant Industry Station, Beltsville, Maryland by April 15. Along with the title please include (a) approximate time required to present your papers, (b) if an illustrated talk, the size of the slides to be used, and (c) the names and official addresses of the authors as you wish them to appear on the program. As has been our custom, we will again distribute mimeographed abstracts of these papers to persons attending the annual meeting. Abstracts should accompany the titles of the papers and are limited to 150 words.

We would like to receive good papers concerned with problems in potato breeding, diseases, production, quality, nutrition, storage, transportation, and marketing.

Your cooperation in sending in titles and abstracts as early as possible will aid in the mimeographing of these abstracts and the prompt preparation and printing of programs. Titles received after the deadline may not be accepted. Please bring this notice to the attention of your students and colleagues.

R. V. AKELEY, *Secretary*

BOOK REVIEW

Freezing Preservation of Foods. Third Edition. by Donald K. Tressler and Clifford F. Evers. Avi Publishing Company, Inc., Westport, Connecticut. 1957. In two volumes. Volume II—Freezing of Precooked and Prepared Foods. 559 pages, 125 illustrations, 66 tables, and 13 pages of front material. Price $10.00 postpaid, domestic; $11.00 postpaid, foreign.

This volume on Freezing of Precooked and Prepared Foods along with its companion volume (1), Freezing of Fresh Foods, provide a complete compilation of information pertaining to the freezing preservation of foods. The authors have the assistance of one hundred and thirty scientists collaborating in the preparation of the two volumes. Emphasis is on the commercial freezing of the foods but the home care of the frozen foods and home freezing are not neglected.

Volume II covers the preparing, packaging, freezing, storing, transporting, marketing, and serving of practically every conceivable prepared or precooked food. In addition to those foods normally thought of as being prepared or precooked there are directions pertaining to baked goods, hors d'oeuvres, sauces, gravies, confections, and complete meals, both foreign and domestic

Thirteen pages are devoted to the freezing of the several types of cooked potatoes. Specific directions for large scale preparation of French fries, whipped, mashed, hash brown, puffs, cakes, baked, *etc.*, are given. Packaging, freezing technics, and storage of same are discussed.

A comprehensive reference book for the commercial freezing of precooked and prepared foods.

WALTER A. MACLINN, *Chairman, Department of Food Technology, Rutgers University*